Quarterly Technical Progress Report
for the period ending March 31, 2001

METHANE de-NOX® for Utility PC Boilers

Covering Period: January 1, 2001 to March 31, 2001

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Date of Report: April 26, 2001

Award Number: DE-FC26-00NT40752

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Gas Research Institute (GRI)
All-Russian Thermal Engineering Institute (VTI)

DISCLAIMER

ABSTRACT

The overall project objective is the development and validation of an innovative coal combustion system, based on a novel coal preheating concept prior to combustion, that can reduce NO_x emissions to 0.15 lb/million Btu or less on utility pulverized coal (PC) boilers without the need for post-combustion cleaning. Work during the quarter included initiation of the equipment fabrication effort for all pilot system components. Fabrication of the gas-fired combustor was started and completed by IGT during the quarter. The combustor was then installed in IGT's combustion laboratory for proof-of-performance testing prior to shipping to BBP for installation in the pilot-scale test system. A testing procedure and performance goals were developed for the combustor testing

EXECUTIVE SUMMARY

Project Objective: The overall project objective is the development and validation of an innovative combustion system, based on a novel coal preheating concept prior to combustion, that can reduce NO_x emissions to 0.15 lb/million Btu or less on utility pulverized coal (PC) boilers. This NO_x reduction should be achieved without loss of boiler efficiency or operating stability, and at more than 25% lower levelized cost than state-of-the-art SCR technology. A further objective is to make this technology ready for full-scale commercial deployment by 2002-2003 in order to meet an anticipated market demand for NO_x reduction technologies resulting from the EPA's NO_x SIP call.

Background: Conventional measures for NO_x reduction in PC combustion processes primarily rely on combustion modifications and post combustion controls. In general, combustion modification technologies try to reduce the formation of NO_x precursors while destroying already-formed NO_x. A variety of NO_x reduction technologies are in use today, including Low-NO_x Burners (LNB's), flue gas recirculation (FGR), and gas or other fuel reburning. Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR) are post combustion techniques. NO_x reduction efficiencies from these technologies vary from 30 to 60%, with up to 90% for SCR.

A novel pulverized coal-preheating approach for NO_x reduction has been developed by the All Russian Thermal Engineering Institute (VTI), in Russia, for use on PC utility boilers. The technology consists of a burner modification that preheats pulverized coal to elevated temperatures (up to 1500°F) prior to coal combustion. This releases coal volatiles, including fuel-bound nitrogen compounds, into a reducing environment, which converts the coal-derived nitrogen compounds to molecular N_2. The quantity of natural gas fuel required for PC preheating is in the range of 3 to 5% of the total burner heat input. Basic combustion research and development of the preheat PC burner was conducted by VTI in the early 1980's. Following these promising laboratory results, commercial-scale coal preheat burners of 30 and 60 MW_t capacity were developed and demonstrated in field tests conducted in several Russian power stations.

The advanced pulverized coal (PC) preheat combustion system being developed in this project for direct-fired PC boilers combines the modified VTI preheat burner together with elements of

IGT's successful METHANE de-NOX technology for NO_x reduction. METHANE de-NOX has been commercially demonstrated on coal, MSW and biomass-fired stoker boilers in the U.S. and Japan. Overall, the new PC preheat system combines several NO_x reduction strategies into an integrated, low-NO_x, PC combustion system, including a novel PC burner design using natural gas-fired coal preheating, and internal and external combustion staging in the primary and secondary combustion zones. This integrated system can achieve very low NO_x levels – down to 0.15 lb/million Btu – without the complications, limitations and expense of SCR or SNCR technology.

Status:

Work during the quarter included selection of a fabricator for the pilot-scale test system and initiation of the equipment fabrication effort for all pilot system components except the gas-fired preheat combustor under BBP's expanded subcontract. Fabrication of the gas-fired combustor was started and completed by IGT during the quarter. The combustor was then installed in IGT's combustion laboratory for proof-of-performance testing prior to shipping to BBP for installation in the pilot-scale test system. A testing procedure and performance goals were developed for the combustor testing. Completion of combustor testing at IGT is expected by the end of May. Delivery of the balance of the pilot scale system equipment to BBP is scheduled for mid-May. Installation of all pilot scale equipment, including the gas-fired combustor, in BBP's 3 MMBtu/h test facility is expected to be completed by mid to late June.

EXPERIMENTAL

Task 1.1 *Pilot-Scale Design*

The pilot-scale system design development was completed and reported during the previous reporting period.[1]

Task 1.2 *CFD Modeling*

Development of a CFD model of the PC preheater was completed during the previous reporting period, along with the modeling study of the 3 MMBtu/h pilot-scale PC Preheat combustor. Modeling of the 100 MMBtu/h PC Preheat prototype system, including the BBP test furnace, will be started once pilot-scale operational data is available.

Task 1.3 *Pilot-Scale Equipment Fabrication and Installation*

Design drawings for the Pilot PC Preheat burner system were completed in the previous quarter. A fabrication subcontract was awarded during the current quarter and delivery of the pilot-scale equipment to the BBP test facility is scheduled for mid-May. Fabrication was completed for the natural gas-fired Preheat combustor, which was then installed in IGT's combustion laboratory for proof-of-performance testing prior to shipping to BBP for installation in the pilot-scale test system. A schematic of IGT's PC combustor test rig is shown in Figure 1.

[1] Quarterly Technical Progress Report for the period ending December 31, 2000 "METHANE de-NOX® for Utility PC Boilers, " DE-FC26-00NT40752

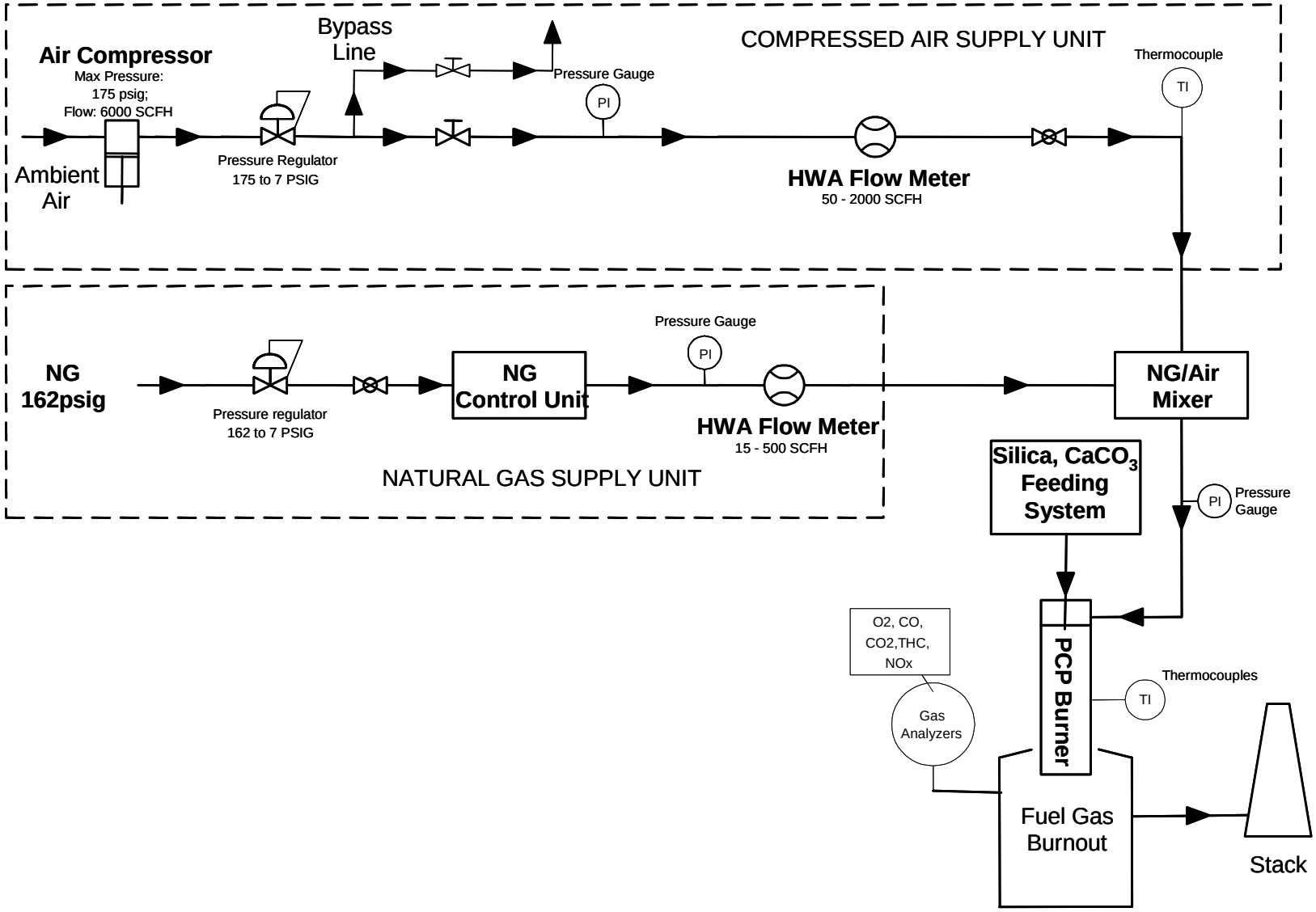

Figure 1. PC Preheat Burner System Combustor Test Arrangement in IGT's Combustion Laboratory

Proof of performance testing at IGT will include:

- Startup testing to insure the combustor reputably achieves stable operation in the 2000°F range within 5-10 minute of lightoff.
- Confirmation of stable combustor operation at near-stoichiometric combustion air flow
- Testing with inert solids feed to the combustor to simulate operation with pulverized coal
  - tests with silica to simulate heating of coal particles in the combustor (similar density and heat capacity)
  - test with mixture of silica and $CaCO_3$ to simulate additional devolatilization heat load due to coal pyrolysis

Installation of the PC Preheat burner in IGT's combustion laboratory is shown in Figures 2 and 3 below. Proof-of-performance testing of the combustor is scheduled for completion by the end of May. The combustor will then be shipped to BBP for installation in the pilot-scale PC Preheat test system.

Figure 2. PC Preheat combustor unit - view from the top of the sectional furnace

Figure 3. PC Preheat combustor, sectional furnace, gas and air supply skid, and controls

Task 1.4 *Pilot-Scale Testing*

Installation of the pilot-scale (3 MMBtu/h) PC Preheat system at BBP's burner test facility is scheduled for completion in mid-June. Upon completion of system checkout and commissioning, pilot-scale operation with two modes of pulverized coal delivery, a bin storage delivery system and a direct-fired delivery system will be evaluated. Key operating variables to be tested are coal type, preheat temperature and coal residence time at temperature prior to the coal combustor.

Task 1.5 *Pilot-Scale Data Evaluation* – No Activity

Task 1.6 *Task 1 Management and Reporting*

Work during the quarter included project review and planning correspondence with VTI and BBP, follow-up with vendors for pilot-scale test system and natural gas-fired combustor, and follow-up on the contract modification with BBP for the additional design and fabrication work on the pilot system added to BBP's subcontract workscope.

Plans for Next Quarter:

- The 3 MMBtu/h pilot-scale preheat combustor testing at IGT will be completed and then shipped to the BBP test facility for installation in the pilot-scale PC Preheat test system.
- The balance of the pilot-scale test system will be installed at BBP.

Milestone Status Table: The planned completion dates for all project tasks and major milestones are shown in the following table. As of this date, IGT expects the overall project to be completed on schedule in August 2002.

ID No.	Task / Milestone Description	Planned Completion	Actual Completion	Comments
♦	Kickoff Meeting	5/2/2000	5/2/2000	Complete
1.0	Technology Development			
1.1	Pilot-Scale Design	8/31/2000	12/31/2000	Complete
1.2	CFD Modeling	6/30/2001		Pilot-scale modeling complete
1.3	Pilot-Scale Equipment Fabrication and Installation	11/30/2000		Completion expected 6/2001
1.4	Pilot-Scale Testing	3/31/2001		Testing to start 7/2001
1.5	Pilot-Scale Data Evaluation	4/30/2001		Completion expected 8/2001
1.6	Task 1 Management and Reporting	4/30/2001		Completion expected 9/2001
♦	Task 1 Report	4/30/2001		Completion expected 9/2001
2.0	Technology Validation			
2.1	Commercial Prototype Engineering Design	7/31/2001		
2.2	Baseline Data Review	7/31/2001		
2.3	Commercial Prototype Construction	10/31/2001		
2.4	Commercial Prototype Testing	2/15/2002		
2.5	Data Processing and Evaluation	3/31/2002		
2.6	Commercialization Plan Development	6/15/2002		
2.7	Design and Fabrication of Commercial Burner System	7/31/2002		
2.8	Task 2 Management and Reporting	8/10/2002		
♦	Final Report	8/10/2002		